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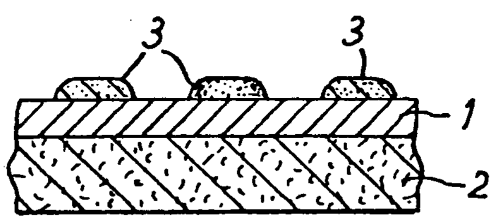
(54) Improvements in coated abrasives.

(57) Coated abrasives comprising a sheet (1) of paper or fabric coated with abrasive particles in an adhesive binder are made more flexible and longer-lasting by applying the abrasive particles in the binder in an array of discrete dots (3) covering only part of the area of the sheet. The performance of the product is further improved by the use of a backing sheet (2) of flexible synthetic foam material.

The products are sanding sheets which may be made into belts or discs for use on machines and tools, cleaning and polishing sheets, and dishwashing pads.



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IMPROVEMENTS IN COATED ABRASIVES

INTRODUCTION

Current coated abrasives i.e. paper or fabric substrates coated with an adhesive binder in which is embedded one layer of abrasive grit particles, have four important disadvantages:-

1) Brittleness. Because the grit particles have to be very firmly bonded to the substrate, the adhesive binder tends to be of a hard, resinous natur . The product therefore, tends to be stiff (in spite of its flexible substrate) and often breaks down quickly in use because the brittle coating is easily damaged and breaks up from the area of damage.
2) Clogging. The nature of the continuous surface of a typical sandpaper is such that it tends to clog up fairly quickly with abraded debris whilst being used. The only exceptions are the more expensive sanding sheets that can be used 'wet'.
3) Cutting Rate. As a consequence of the single grit layer, traditional abrasive sheets show markedly different rates of cutting depending on the amount of use the sheet has had. A fresh sheet cuts fastest and declines rapidly in abrasiveness as the sheet wears.
4) Short Life. As well as the problems of cracking and clogging, the life of a sanding sheet is shortened by:-
   a) Particles of grit being torn from the surface during use.
   b) The grit surface wearing and quickly losing its cutting edge.

   Since the abrasive surface of the typical sheet comprises only one layer of grit, loss of the grit by whatever way, will quickly limit the life of the sheet.

Attempts have been made to vercome some of the above disadvantages by:

a) Use of a flexible rubbery binder. This stops any cracking tendencies, but does not solve any of the other problems. Such a product will b inferior in abrading performance due to the resilience of the binder surrounding each grit particle, and must usually be used 'wet' with water.

b) Lowering of grit coating density i.e. putting fewer particles of grit on the surface with large areas between the grits certainly reduces the tendency to clog. However, because it has fewer particles of grit per unit area, such a sheet is less effective as an abrasive and the isolated grit particles are more easily torn from the surface during use.

It has been found that by applying the grit in a non-continuous but regular way by stencilling it and/or its adhesive binder as a pattern of dots or discs onto the usual flexible substrates, abrasive sheets can be made which overcome all of the disadvantages listed above.

Thus in accordance with the present invention there is provided an abrasive sheet comprising a flexible substrate carrying a multiplicity of discrete dots each consisting of an adhesive binder material containing abrasive or other mineral particles. The dots are conveniently, but not necessarily, circular in plan. They may have the form of heaps or mounds of material or may be flattened to a disc. Conveniently, but again not necessarily, they are arranged in a regular array, for example in rows with the dots in alternative rows mid-way between pairs of dots in each of the adjacent rows. The area between the dots is preferably left entirely untreated and free of applied material in order to preserve the flexibility of the substrate.

The abrasive sheet in accordance with the invention can be manufactured by stencilling through a perforated plate, either using a mixture of abrasive particles and binder or employing binder alone. In the latter case the abrasive particles are applied subsequently before the binder is hardened.

<u>METHOD</u>

An adhesive ink is prepared. Its properties must be such that it initially behaves in a satisfactory way whilst being

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stencilled, then holds its stencilled shape during the subsequent drying and hardening operations. It must then of course behave as an extremely effective adhesive to hold the various types of grits to the substrates and maintain this adhesion in use when the sheet might become quite hot. In many applications it will also be required to be water or oil resistant.

Having prepared the adhesive ink, either of two procedures can be followed:-

1) The abrasive grit is simply stirred into the adhesive ink and the mixture stencilled onto the chosen substrate. The resulting dots/discs are dried and cured to maximum hardness. They may be hot pressed after drying and before curing should a uniformly flat disc be required.

   This is the preferred method where many layers of grit are required in the finished coating dots.

2) The unfilled or partially filled adhesive ink is stencilled onto the substrate and whilst the adhesive dots are still wet or molten they are impregnated with the required grit by any of the various techniques of dipping, sprinkling, electrostatic spraying, passing through a fluidised bed of grit etc. The gritted dots can then be compressed lightly to consolidate adhesion of the grit and then dried and cured. This is the preferred method where only 1-2 layers of grit are required in the coating.

COATED PROCEDURE. The adhesive ink will be almost paste-like in its rheology, especially if already filled with grit. In the simplest procedure, the substrate material is laid out on a flat surface upon which is a 2mm layer of soft rubber and the perforated stencil screen in the form of a flat sheet is placed on top. The edges may be held down with clips. The adhesive ink is spread out across one end of the stencil and then smeared across the stencil using a tough rubber squeegee blade. The substrate and stencil are then peeled apart after which the abrasive grit can be added if following the method (2) above. Either way, the dots can be dried and cured by placing the substrate sheet into an oven at a temperature/time appropriate to the chemistry of the particular adhesive binder. The dots can be pressed prior to, or during the curing stage to ensure that each one has the same height and a similar profile, and/or to increase the area covered by each dot beyond that given by the

pattern in the particular stencil screen. Thus, a conventional flat-bed screen printing machine can be easily converted for the production of this abrasive sheet. Alternative, a rotary technique may be used, where the stencil screen is in the form of a cylinder. This rotary method is continuous and is preferred where a high output is needed using a continuous web of base material. Long drying tunnels are of course essential in this latter method, although reels of dried, coated base can be subsequently cured in simple ovens where necessary.

A more detailed description will now be given by way of example with reference to the accompanying drawings, in which:-

Fig. 1 is a plan view of part of an abrasive sheet in accordance with one embodiment of the invention,

Fig. 2 is an enlarged section on the line II-II in Fig.1,

Fig. 3 is a side view and Fig. 4 is an end view of the equipment used for carrying out a "brick test" for measuring the performance of abrasive sheets, and

Fig. 5 is a side elevation of the apparatus used for carrying out a "power tool test" which also measures the performance of abrasive sheets.

Referring to Figs. 1 and 2 a paper sheet 1 has a backing layer 2 of flexible synthetic plastics foam material for a purpose to be described. The front face of the sheet 1 carries a plurality of flattened circular dots 3 consisting of abrasive particles in a resin binder which serves to bind the particles together and adhere them to the sheet. It can be seen that the dots 3 are in a regular array consisting of rows in each of which the dots are equally spaced by a distance s, every other row being offset by an amount equal to half the centre-to-centre spacing of the dots.

SPECIFICATIONS AND FORMULATIONS

STENCIL-SCREENS

Material	....	metal or plastics
Thickness	....	0.3 to 3.0 mm.
Holes	....	1.0 to 10.0 mm. diameters
Open Area	....	20 to 50%

Choice and selection of pattern and thickness is related to grit size, nature of the substrate and required end-use of sheet. As a general guide, the ratio of hole diameter (d) to stencil thickness (t) should be at least 3:1 and preferably more than 4:1 i.e. $\frac{d}{t} \geqslant 3$

While the open area of the stencil is not usually greater than 50%, flattening of the dots after stencilling will increase the area covered by the dots up to as much as 60% of the total area of the sheet.

For a general purpose sanding sheet of "fine to medium" grade (i.e. grit sizes having B.S.S. mesh number $>$ 80) the following stencil dimensions are chosen:

Holes	....	2.85 mm. diameter.
Thickness	....	0.50 mm.
Open Area	....	About 50%
Material	....	Stainless Steel.

A coarse grade (i.e. grit Nos.'s below 70 mesh) will be satisfactory through the above screen, but will not produce as many layers of grit in each dot as the smaller grits.

Better screens are:-	I	II
Holes	4.00 mm. diameter	6.38 mm diameter.
Thickness	0.70 mm.	0.80 mm.
Open Area	About 45%	47%
Material	Stainless Steel	Stainless Steel

The larger diameter of the discs also results in better overall adhesion of the dots/discs to the substrate which is useful since "coarse" grades of abrasive sheets are often used in the severest way. When, however, maximum rate of cut and/or maximum working life is required from the final sheet irrespective of grit size, or coating weight, then the largest diameter dots should be specified.

It should be noted that when the stencilling is carried out against a soft rubber beneath the substrate, the final height of the stencilled dot can be up to 2 - 3 times the thickness of the stencil, according to the pressure applied to the squeegee during the printing stroke.

ABRASIVE GRITS

These can be any of the known abrasive materials e.g. diamond, boron nitride, tungsten carbide, silicon carbide, aluminium oxide, emery, garnet, various sands, flints, glasses etc. Particle sizes will typically be from B.S.S. mesh number 1000 up to heavy 20 mesh grits, i.e. particle diameters of about 20μ to 1000μ. For the purpose of classifying the grades possible with the new dot coated product, five grit size ranges have been identified:-

	Approximate grit diameter in microns	British Standard Sieve Mesh Number (B.S.S.No.)
i. Medium (general purpose) grade	150	100 - 120
ii. Coarse	250	70 - 90
iii. Very Coarse	500	30 - 60
iv. Fine	60	150 - 250
v. Very Fine	40	above 300

BASE This can be the usual heavy kraft papers and paper laminates associated with conventional sandpapers; waterproofed papers of various weights; textile bases (woven or non-woven) of cotton, canvas, cellulose acetate, polyester, polyamide etc., plastics or metal foil, or any flexible laminate of the above. It has been found that the use of a plastics foam sheet laminated to the back of an abrasive dot-coated paper or textile base intended for hand-use improves the performance of the product. This improvement presumably occurs because the foam backing evens-out any high pressure spots during sanding and allows the dots of abrasive to "float" to a certain degree. For some hand applications, it also enables the new sheets to be used satisfactorily without a sanding block as backup.

The preferred bases are:-

a) Kraft Paper at 100 - 300 g/m^2 weight, waterproofed.

b) Simple woven cottons at 50 - 250 g/m^2

The preferred foam-backings are:

c) For hand sheets and Orbital Sander sheets
Cross-linked low density polyethylene foam, density 20 - 70 Kg/m^2, at a thickness of 2 - 5 mm.

d) For discs for power sanders
Cross-linked high density polyethylene foam, density 90 - 120 Kg/m^3, at a thickness of 2 - 3 mm.

These foams are laminated to the abrasive dot coated base materials by either conventional flame-bonding techniques, or by the use of appropriate adhesives.

ADHESIVE INK Various recipes have been developed based upon the following resins or blends: Formaldehyde resins (as phenolic, urea, melamine), Epoxide, Polyamide, Poly(vinylacetate), Poly(Vinyl chloride) and its copolymers, natural gums, gelatin. Other resins which would probably be useful are: Furanes, Polyamides, Acrylics, Polyurethanes, Silicones, etc. The inks can be solvent or water based. Any resin powders should have a particle size of less than 60μ. There is obviously a great deal of scope for the development of improved adhesive inks.

In formulating the adhesive ink, it has been useful to identify the grit-to-resin binder ratio as a guide to the end-product design. For example, for a general-purpose dot-coated abrasive sheet a grit-to-binder ratio of about 5 : 1 is suitable, if the base is paper, and the binder contains thermosetting resin. At this ratio, the abrasive dots show good adhesion to the base paper, excellent abrasive properties and a low wear rate in use. Should it be required to have a faster rate of wear (grit loss) as, for example, if the sheet is to be used for cutting the surface of metals, then the grit-to-binder ratio should be increased to 7 or 8:1. (This is important where metals tend to smear into the abrasive surface and clog it, especially if the grits are fine).

On the other hand, a more absorbent backing such as a woven cotton needs proportionately more resin in the mix to achieve adequate adhesion of the stencilled dots to the base fabric. In this case, a grit-to-binder ratio of 2 or 3 : 1 is more appropriate.

COATING WEIGHTS These will depend to a great extent on the size of grit used, whether or not multilayers are present, and the area taken up by the stencilled dots. They will range between 50 - 1000 g/m^2 (total, dried and cured dots). By way of example, a general purpose sanding sheet, based on Aluminium Oxide grit at a grit-to-binder ratio of 5 : 1, and stencilled through the preferred screens as specified, will have complete, dried coating weights of:

a) Medium or Fine grades, at 200 - 300 g/m^2

b) Coarse grades, at 400 - 600 g/m^2

The references a) to k) in the following examples are to the table of "Raw Materials and Suppliers" which is appended to this specification and gives further details of the materials used.

SOME EXAMPLES

1. A simple sandpaper

		parts by weight
a)	Poly(vinyl chloride) copolymer powder	25
	Di-iso-octyl phthalate	15
c)	Acrylic thickener	2
	Water	5-10
	Sand or Flint grit (80 mesh - 320 mesh)	100

Screen 2.85 mm hole as specified under "Stencil Screens"

Base Kraftpaper at about 150 g/m^2

After stencilling, the dots are first dried at 90°C for two minutes to drive out the water, then at 150°C for a further 2 minutes to flux and consolidate the resin.

This is a product incorporating the cheapest raw materials, and with a very fast drying rate. It is useful for the hand sanding of wood, paintwork, fillers etc., in the dry state.

2. An improved sandpaper

a)	Poly(vinyl chloride) copolymer powder	25
	Di-iso-octyl phthalate	15
c)	Acrylic thickener	2.5
h,I)	Phenol Formaldehyde Resin as (80% Resol solution in water)	5
	Lactic Acid (concentrated aqueous solution)	1
	Sand or Flint (80 - 320 mesh)	125
	Water	5

Same screen as (1), similar kraftpaper but preferably waterproofed.

After stencilling, the dots are dried for 2 minutes at 90°C, then 15 minutes at 125°C.

This product is an improved version of (1). It lasts slightly longer, and can be used wetted with water for short periods.

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3. <u>More durable sheet based on a thermosetting resin</u>

e)	Nylon 12 terypolymer powder	10
	Water	10 - 20
d)	Poly(vinyl alcohol) 15% aqueous solution	8
f)	Epoxide Resin Liquid	2.5
g)	Polyamide hardener	2.5
i)	Grit, either emery or silicon carbide or aluminium oxide.	30* - 80

Stencil as for (1) and (2).
Base: either woven cotton at 70 g/m^2 weight *(use 30 parts grit), or waterproofed kraft paper 150 g/m^2 (use 80 parts grit).
After drying for 1 minute at 90°C, the sheet is cured for 5 minutes at 150°C.

The completed sheets can be presented in various ways according to the end use. For example, the emery coated cotton can be laminated to kraft paper at about 100 g/m^2 or L.D.poly(ethylene) foam at 2 mm. and cut into strips for metalworking. Alternatively, the paper coated versions can be laminated to foam or the cotton fabric, or both, to make very tough, durable sanding sheets. Textile-containing laminates are suitable for making into belts for use on sanding machines.
This product may be used dry or wet with water or oils.

4. <u>A solvent based adhesive ink</u>

e)	Nylon 12 Terpolymer powder	5)	predissolved at 50°C
	Isopropyl alcohol	25)	
h,II)	Phenol Formaldehyde resin powder (novolak + hexamine)	8	
b)	Poly(vinyl chloride) homopolymer. (50% resin emulsion in water)	10	
i)	Grit	90	

Stencils - as specified. Base is waterproofed kraft paper at 150 g/m^2.

The paste must be kept at about 30°C to keep the nylon resin in solution. After coating, the sheet is dried for 2 minutes at 70°C, then 1 hour at 125°C to cure. The finished sheet may be laminated to foam as previously described. It has excellent abrasion performance both dry and wetted with water or oils, and is very long lasting.

5. <u>A general purpose formulation for commercial use.</u>

		Parts by weight
b)	Poly(vinyl chloride) homopolymer (50% resin emulsion in water)	50
d)	Poly(vinyl alcohol), 15% aqueous solution	10
f)	Epoxide Resin Liquid	25
	Tetraethylene pentamine	5
c)	Acrylic thickener	1
i)	Grit	250

Pot life is 3 - 4 hours at room temperatu

This particular adhesive has the best properties as a stencil paste, It can tolerate the widest range of grit sizes (mesh No. 40 upwards) in grit-to-binder ratios of up to 10 : 1.

Stencils - as specified.

Bases - kraft papers, textiles.

After stencilling, the sheet is dried for 1 minute at 90°C, then 5 minutes at 150°C to cure. This system is easy to control and vary, and gives a good product for general use, especially when foam-backed.

It is economical to make with a very short curing time. Its only disadvantage is that its water resistance is only fair so that it can only be used for intermittent "wet" sanding.

6. <u>Superior grade for wet or dry use</u>

This is based on the previous formulation (5), with increased phenolic resin content, plus the addition of a polyamide curing agent for the epoxide resin.

b)	Poly(vinyl chloride) homopolymer (50% resin emulsion in water)	5
f)	Epoxide resin liquid	15
	Water	20 - 30 according to grit size
	Tetraethylene pentamine	1
g)	Polyamide resin liquid	5
h,II)	Phenol Formaldehyde resin powder (as novolak + hexamine)	10
c)	Acrylic Thickener	2.5
i)	Grit	160

Pot Life is several hours at room temperature.

Stencils as previously specified.
Base - waterproofed kraftpaper at 150°C.
After stencilling, the sheet is dried for 2 minutes at 90°C., then cured for 2 hours at 125°C.
This product is straightforward to make and has excellent abrasive properties, both dry and wetted with water or oils. It is also excellent for use with power tools in the form of textile-backed belts, or foam-backed sheets or discs.

TESTS

All tests and evaluations have been conducted on the products from formulation No. 6, using aluminium oxide or silicon carbide as follows:-

grade	grit mesh number (British Standard Sieve)	stencil	approximate coating weight (dry)
Fine	220	holes = 2.85 mm.dia.	200 g/m^2
Medium	100	thickness = 0.50 mm. open area = 50%	250 g/m^2
Medium	100	holes = 6.38 mm.dia.	
Coarse	80	thickness = 0.80 mm.	550 g/m^2
		open area = 47%	

Base is waterproofed kraftpaper at 146 g/m^2
Where foam-backed samples are mentioned, they are all 2 mm. crosslinked poly(ethylene), either low density for hand sheets and orbital sander sheets, or high density for sanding discs.

Sizes

Hand Sheet	at	5½" x 9"	(140 mm.x 229 mm).
Orbital Sheet	at	3⅝" x 9½"	(92 mm.x 241 mm).
Discs	at	5" diameter	(127 mm. dia.)

a) Brick Test

Adhesion, abrasiveness, durability, and comparison with current commercial coated abrasives are assessed by the "brick test" as follows:-

A small refractory brick (specification unknown) is used as a "standard surface" to be abraded. Under a fixed weight, it is rubbed by hand against the surface of the abrasive sheet being tested. The brick is 4 cm. x 4 cm. x 1.5 cm. in size, and weighs 50 g. One edge (i.e. 4 x 1.5 cm.) is used for the test. A weight of 1.5 Kg. is fixed to the opposite face of the brick, producing a force of about 0.25 Kg/cm^2 at the surface in contact with abrasive sheet. This corresponds approximately to a typical sanding situation under heavy hand pressure.

The abrasive sheet 10 to be tested (see Figs. 3 and 4) is placed on a hard flat surface 11 with the abrasive surface 12 uppermost. The brick 13 carrying a weight 14 is placed in the centre of the sheet and carefully moved up and down (by hand) along a path of about 10 cm. as indicated by the arrows 15 thus making a test patch of area about 2 cm. x 10 cm. A "stroke" is counted as one complete up and down movement along this patch. The test sheet is first weighed, then subjected to an abrasion cycle of 50 strokes, after which the sheet, plus the abraded brick dust still in its surface, is carefully reweighed. Then the brick dust is brushed away, the sheet weighed again, and the cycle of 50 abrasion strokes repeated along the same patch. This routine is continued until abrasiveness has nearly disappeared or until about half the grit in the test patch has been worn away leaving bare basepaper, at which point the sheet is considered worn out. It was interesting to note that it was always necessary to brus the traditional sheets to remove the debris, whereas the new stencilled sheets could be cleared of dust by just tapping the sheet from behind. In a second series of tests, the test sheets were first soaked in water fc six hours at room temperature. They were then abraded in a similar way as above, using plenty of cold water at the surface, but continuously until the sheet was worn out.

The results of the Brick Test are given in the following tables:-

	SAMPLE AND GRADE	GRIT TYPE AND B.S.S.MESH NO.	APPROX. COATING WEIGHT	WET TEST NUMBER OF STROKES TO WEAR OUT TEST PATCH
1	ENGLISH ABRASIVES ATLAS BRAND ALUMINIUM OXIDE PAPER 134 MEDIUM	ALUMINIUM OXIDE 100	200g/m^2	not waterproof
2	ditto, with foam Backing MEDIUM	"	"	" "
3	ENGLISH ABRASIVES WATERPROOF SILICON CARBIDE PAPER 166 MEDIUM	SILICON CARBIDE 120	230g/m^2	39
4	ditto, with foam Backing MEDIUM	"	"	129
5	STENCILLED PRODUCT MEDIUM SCREEN AT 0.5mm thick 2.85 mm.Dot.Dia.	ALUMINIUM OXIDE 100	240g/m^2	53
6	ditto, with foam backing MEDIUM	"	"	460
7	STENCILLED PRODUCT MEDIUM SCREEN AT 0.8mm thick 6.38mm Dot.Dia.	"	550g/m^2	212
8	ditto, with foam backing MEDIUM	"	"	546
9	3M PRODUCTIONS PAPER A wt. OPEN COAT P 220 FINE	ALUMINIUM OXIDE 220	80g/m^2	not waterproof
10	ditto, with foam backing FINE	"	"	" "
11	STENCILLED PRODUCT FINE SCREEN AT 0.5mm thick 2.85mm Dot.Dia.	"	220g/m^2	
12	ditto, with foam backing FINE	"	"	93
13	STENCILLED PRODUCT FINE SCREEN AT 0.8mm thick 6.38mmDot.Dia.	"	416g/m^2	77
14	ditto, with foam backing FINE	"	"	123
15	ditto, VERY HIGH COATING WEIGHT with foam backing FINE	"	626g/m^2	240
16	ELECTRITE CARBORUNDUM PAPER WATERPROOF 027426 COARSE	SILICON CARBIDE 80	230g/m^2	143
17	ditto, with foam backing COARSE	"	"	217
18	STENCILLED PRODUCT with foam backing SCREEN at 0.8mm thick 6.38mm Dot.Dia. COARSE	"	560g/m^2	1,812

	WEIGHT OF BRICK REMOVED IN: (grammes) 1st 50 STROKES	2nd 50 STROKES	3rd 50 STROKES	4th 50 STROKES	5th. 50 STROKES	NUMBER OF 50 STROKE CYCLES TO WEAR OUT TEST PATCH	TOTAL WEIGHT OF BRICK REMOVED
1	0.14	0.14	0.11	0.09	0.08	5	0.56 g
2	0.14	0.10	0.10	0.10	0.09	18	1.28 g
3	0.15	0.14	0.05	-	-	3	0.34 g
4	0.23	0.15	0.14	0.12	0.13	12	1.63 g
5	0.15	0.11	0.12	0.10	0.10	6	0.68 g
6	0.20	0.14	0.15	0.13	0.11	26	3.23 g
7	0.27	0.34	0.45	0.38	0.41	7	2.10 g
8	0.27	0.28	0.28	0.28	0.31	25	7.40 g
9	0.05	-	-	-	-	1	0.05 g
10	0.03	0.02	0.02	0.01	0.02	6	0.11 g
11	0.13	0.13	0.04	-	-	3	0.30 g
12	0.12	0.10	0.08	0.07	0.05	5	0.42 g
13	0.07	0.10	0.11	0.12	0.12	5	0.52 g
14	0.16	0.15	0.14	0.13	0.13	6	0.83 g
15	0.11	0.11	0.11	0.12	0.14	11	1.38 g
16	0.21	0.20	0.15	0.18	0.17	10	1.85 g
17	0.18	0.12	0.09	0.10	0.10	23	2.04 g
18	0.49	0.36	0.38	0.31	0.39	37	14.19 g

b) Power Tool Test

In this test, the abrasive sheet in the form of a 5" diameter disc 17 (see Fig. 5) is mounted in an electric drill 18 on the heavy rubber backing mount 19 supplied with the particular drill. The disc running at 1800 r.p.m. is then allowed to contact the edge of an ordinary red wallbrick 20 for two minutes under the weight of the tool only. The depth of cut on the leading edge of the brick is then measured.

The assembled disc 17, mount 19 and drill 18 are fixed in the vertical drilling rig 21 supplied for that particular drill. The spring which balances out the weight of the drill is removed from the rig. The wall-brick 20 is held in the drilling vice 22 at the base of the rig so that its longest narrowest side is facing the disc, and positioned so that the outer 2" of the disc contacts one edge of the brick. The brick is also angled at about 10° from the horizontal to balance out the unevenness of the pressure across the disc due to the tapering section of the rubber backing mount.

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The drill is switched on at its maximum speed of 1800 r.p.m. and allowed to rest against the brick for two minutes. The depth of cut on the leading edge of the brick is then recorded. The test is repeated on a fresh part of the same brick.

Drill Black and Decker D520

Brick Soft, red housebrick, "Heather" locally obtained.

Results

ABRASIVE DISC	DEPTH OF CUT (approx.)	STATE OF DISC AFTER TEST
Stencilled Dot (6.38 mm.) Aluminium Oxide No. 80 Foambacked	5 mm.	Very good and unclogged
English Abrasives E OP. Aluminium Oxide Paper 133 Grit No. 80	2 mm.	Nearly worn-out and clogged.

All the commercial samples used in the tests were purchased at random from local shops.

Discussion of Results.

Brick Test. (a) All the commercial sheets gave the anticipated level of performance, and were surprisingly improved when foam-backed for a more direct comparison with the new stencilled sheets. Although the new stencilled sheets were better than the equivalent traditional abrasive sheet in the unbacked form, they were vastly better when foam-backed. It is quite likely that formulation number 6 is producing a stencilled dot which is slightly too brittle to give optimum performance in the unbacked 2.85 mm. dot form.

The total weight of brick removed during each abrasion test gives a direct value to the "abrasive capacity" of each sample. For example, the commercial grade of "medium" aluminium oxide paper (English Abrasives Atlas Brand) removed 0.56 g. of brick dust before wearing out. The equivalent grades of stencilled

products (foambacked) removed 3.23 g. and 7.40 g. respectively for small and large dot sizes, i.e. 5.8 and 13.2 times better. The rate of cut was about equivalent between the Atlas Brand and the small dot sheet, but nearly three times faster with the large dot sheet. This unexpected result indicates that the edge of the abrasive dots is acting as a second source of abrasion. Therefore, the diameter of the dots is an important factor in the design of the new abrasive sheets as it is now possible to achieve high removal rates without being confined to the use of coarse grits (and hence coarse finishes). Looking at the other grades, the "fine" stencilled product (small dots, foambacked) had about 8 times the abrasive capacity of the commercial 3M sheet at the same grit size, and cut at about twice the speed. The "fine" samples based on the largest dots showed quite amazing results for such a fine grit size, i.e. a cutting rate more than twice that of the commercial 3M Production Paper, and an abrasive capacity of 1.38 g, which is 27.5 times as much as the 3M sheet. The "coarse" samples, showed that the stencilled product (largest dots, foambacked) had about 7.5 times the abrasive capacity of the commercial Electrite Carborundum sheet, and also cut at twice the rate. The results from the continuous abrasion tests "wet" with water, show that the new stencilled sheet (foambacked) is 10 - 14 times longer-lasting than equivalent commercial grades.

Power Tool Test

This confirms the general results from the refractory brick tests.

Conclusions

The new stencilled abrasive sheets have the following features and advantages over traditional coated abrasives.

1. Much longer lasting, typically 5 - 10 times.
2. Complete flexibility of the sheet due to the discontinuous nature of the coating, and hence the ability to use several layers of grit. All traditional coated abrasives are restricted to one layer of grit.
3. Almost non-clogging and vastly better than traditional coated abrasives in this respect.
4. May be used both dry or wetted with water or oils if formulated from thermosetting resin binders.

Product Range

Practically the entire range of applications of conventional coated abrasives.

i.e. 1) Simple sanding sheets from sands, aluminium oxide, emery or silicon carbide stencilled onto paper or fabrics. Optimum performance from foam-backing.

2) Any of the above incorporating waterproof paper or fabrics.

3) Industrial belts and sanders etc.

4) Discs and other particular shapes for use in power tools.

5) Combinations of any of the above to backings, stiffening materials or special tools for particular uses.

6) Cleaning and Polishing products can be made by using very fine abrasive powders in rubbery binders. These are best used wet.

7) Non-clogging dishwashing pads, where the stencilled dots are excellent for scouring and removing heavy, sticky residues from pots and pans. In this application the abrasive grits are very fine, or replaced by powdered mineral fillers such as chalk or slate dust. A thicker foam backing layer is also preferred, for example an open-cell polyurethane foam ½ to 1 inch in thickness (1.0 - 2.5 cm.)

RAW MATERIALS & SUPPLIERS

a) Poly(vinylchloride) Copolymer Powder
VINNOL VE505/65-10
Wacker-Chemie GmbH,
8 Munchen,
22 Postfach,
West Germany.

b) Poly(vinylchloride), 50% emulsion in water
BREON 4001
B.P.Chemicals International Ltd.,
Devonshire House,
Piccadilly, London.

c) Acrylic Thickener, 15% aqueous solution
COLLACRAL P
B.A.S.F. (U.K.) Ltd.,
P.O.Box 4,
Cheadle Hulme, Cheshire.

d) Poly(Vinyl Alcohol) 15% aqueous solution
POLYVIOL W25/140
Wacker-Chemie

e) Nylon 12 Terpolymer Powder
PLATAMID H105P
Plate Bonn GmbH,
53 Bonn,
P.O.Box 529, West Germany.

f) Liquid Epoxide Resin
DOW DER 321
Casa Chemicals Ltd.,
County Durham.

g) Liquid Polyamide Resin
SYNOLIDE 960
Cray Valley Products Ltd.,
St. Mary Cray, Kent.

h) Phenol Formaldehyde Resins
1. FES 46, 80 resol solution in water
11. TPSx4, Novolak resin and hexamine, powdered to $< 60\,\mu$.
Borden (U.K.) Ltd.,
Baddesley, Southampton.

i) Grits
1. ALUMINIUM OXIDE, REGULAR Al.
Norton Abrasives Ltd.,
Welwyn Garden City, Herts.

11. SILICON CARBIDE, C6 quality
Carborundum Company Ltd.,
P.O.Box 55, Trafford Park,
Manchester.

111. EMERY 182, N. GRADE
Southern Abrasives Ltd.,
New Milton, Hants.

j) Paper Bases
1. HIPLY ABRASIVE BASE PAPER 140 g/m^2
B.S. & W. Whiteley Ltd.,
Otley, West Yorkshire.

11. WATERPROOF KRAFT PAPER IBECO 146 g/m^2
C.Davidson & Sons Ltd.,
Bucksburn, Aberdeen.

k) Foam Backings

1.	LOW DENSITY CROSS LINKED POLYETHYLENE ALVEOLIT 35 Kg/m^3, at 2mm.	Sekisui (U.K.) Ltd., Alma Road, Windsor, Berks.
11.	HIGH DENSITY CROSS LINKED POLYETHYLENE PLASTAZOTE HO62, 90 Kg/m^3 at 2mm.	BXL Ltd., Croydon, Surrey.

CLAIMS:-

1. An abrasive sheet comprising a flexible substrate carrying a multiplicity of discrete dots each consisting of an adhesive binder material containing abrasive or other mineral particles.

2. A sheet as claimed in claim 1 wherein the dots are circular in plan.

3. A sheet as claimed in claim 1 or 2 in which each dot is substantially in the form of a disc.

4. A sheet as claimed in any of the preceding claims in which the dots are in a regular array.

5. A sheet as claimed in any of the preceding claims in which the dots cover from 20% to 60% of the total area of the sheet.

6. A sheet as claimed in any of the preceding claims in which the dots have diameters between 1.0 and 10.0 mm.

7. A sheet as claimed in any of the preceding claims in which the coating weight of the dots, that is the weight of binder material plus mineral particles, is 50 - 1000 g/m^2.

8. A sheet as claimed in any of the preceding claims in which the flexible substrate is a waterproofed kraft paper.

9. A sheet as claimed in any of the preceding claims in which the flexible substrate comprises a layer of woven fabric.

10. A sheet as claimed in any of the preceding claims in which the flexible substrate comprises a carrier layer for the dots and a backing layer of foam material.

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11. A sheet as claimed in claim 10 in which the foam material is a synthetic plastics material.

12. A sheet as claimed in claim 10 in which the foam material is cross-linked polyethylene foam.

13. A sheet as claimed in any of the preceding claims in which the ratio of the weight of mineral particles to the weight of binder is between 1:1 and 10:1.

FIG.1

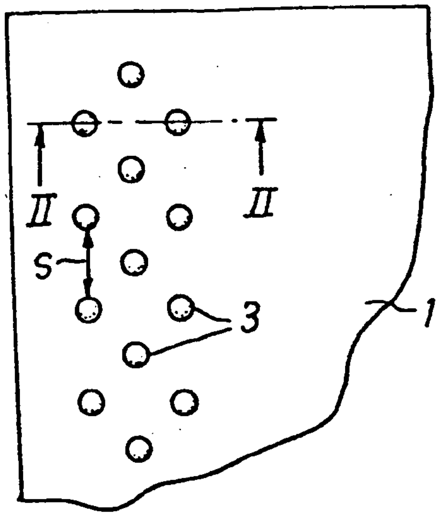

FIG.2

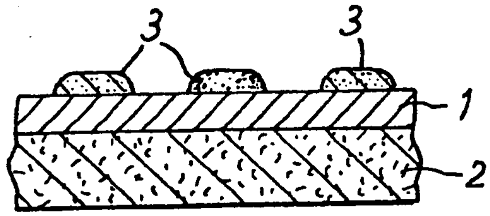

FIG.3

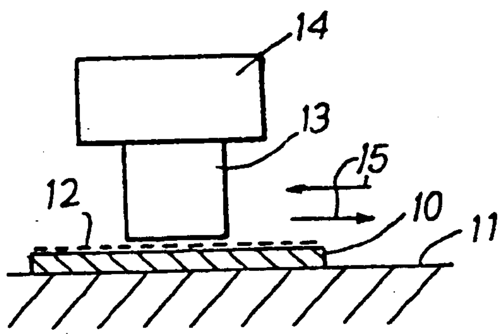

FIG.4

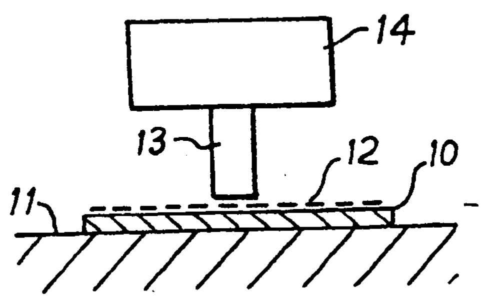

FIG.5